FOREST PEST MANAGEMENT
Pacific Southwest Region

PSW FOREST AND RANGE EXPERIMENT STATION
JUL 12 1985
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Report No. 84-43

3430 Evaluation
November 5, 1984

STATUS OF A WESTERN BUDWORM, CHORISTONEURA CARNANA CALIFORNICA, ON THE WEAVERVILLE RANGER DISTRICT, SHASTA-TRINITY NATIONAL FORESTS - 1984

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ABSTRACT

A western budworm, Choristoneura carnana californica Powell, defoliated Douglas-firs in 1984 on 130,000 acres of mixed ownership within the boundaries of the Weaverville District, Shasta-Trinity National Forests. Egg mass counts were 11/m^2 of foliage - up somewhat from 1983, but well below the counts of 1982. Egg mass ratios indicate an insect population that has stabilized in the outbreak phase over most of the infested area. New or intensified infestations occurred in the upper drainage of Clear Creek, Fools Gulch, Deadwood Gulch, west of Trinity Dam and north of Trinity River Campground. Parasites of the budworm have become abundant. Watershed, recreational quality and wildlife values have not been affected thus far, but the public has now discerned changes in the viewshed brought about by defoliation. Egg mass densities, defoliation and host type distribution indicated an infested area of 140,000 acres in 1985. Management alternatives and considerations for the area are briefly discussed along with the life history of the insect and characteristics of the infested area.

INTRODUCTION

In early June 1982, a detection report from the Weaverille Ranger District indicated that Douglas-firs along Bowerman Ridge and east of Trinity (Clair Engle) Lake were being defoliated by a budworm. The insect involved was Choristoneura carnana californica Powell, a red- and white-colored moth similar to certain forms described for the western spruce budworm, C. occidentalis Freeman. Aerial and ground surveys defined an infestation of approximately 33,000 acres, 5,500 of which were classified as heavily defoliated (Dale 1983, Fig. 1). Very high egg mass densities indicated an intensification of defoliation in 1983.

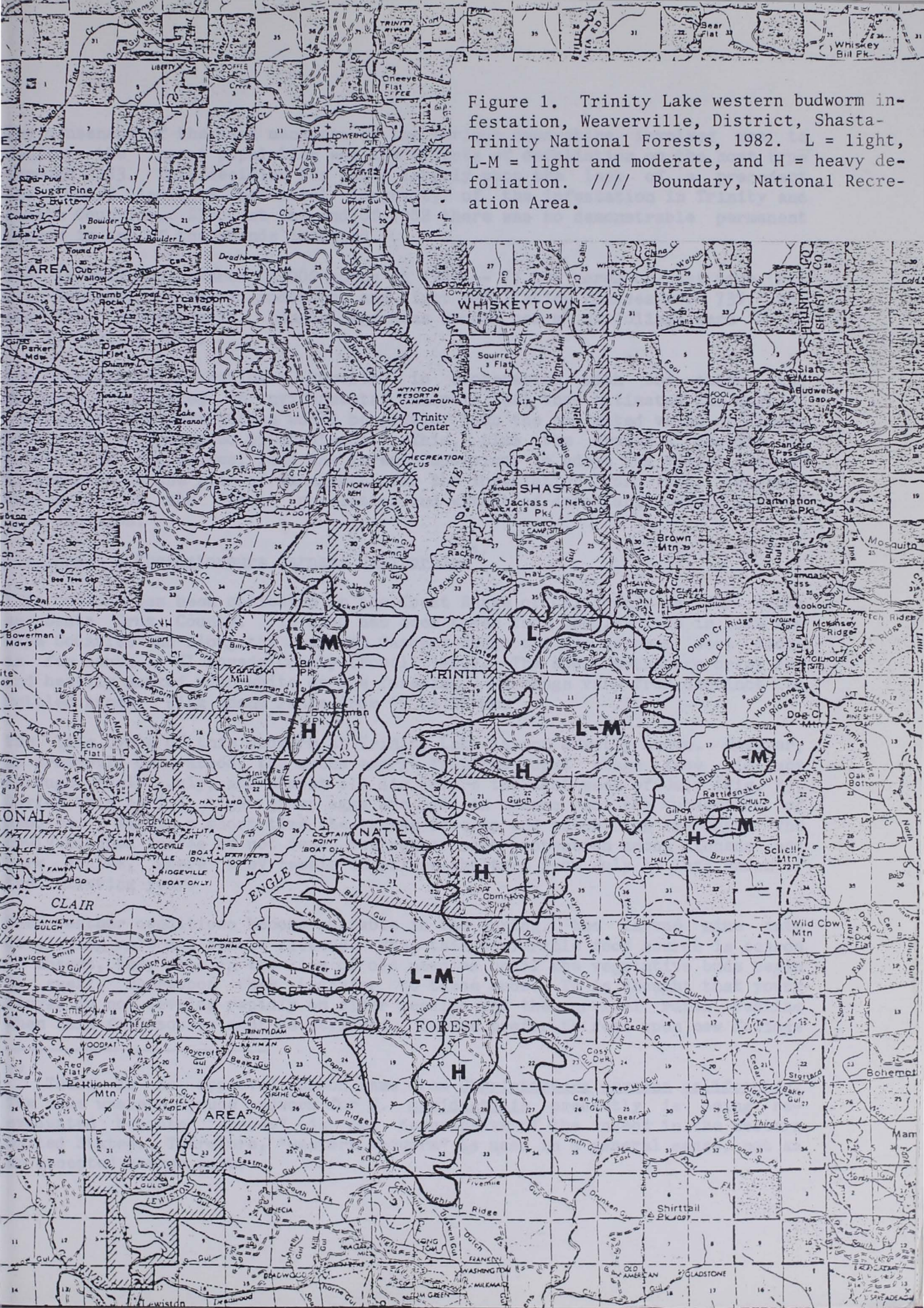

Figure 1. Trinity Lake western budworm infestation, Weaverville, District, Shasta-Trinity National Forests, 1982. L = light, L-M = light and moderate, and H = heavy defoliation. //// Boundary, National Recreation Area.

The consensus of the land managers of the various ownerships involved was to monitor the insect population and the effects of defoliation on the host type through 1983. This decision was based largely upon the lack of a precedent that would indicate potential longevity of the infestation in Trinity and Shasta Counties. Also, at the end of 1982 there was no demonstrable permanent damage in any of the stands infested.

The infestation covered 93,000 acres in 1983 -- 77,000 acres of host type (Fig 2). Estimates on heavy, moderate, and light defoliation classes were 73%, 4%, and 23%, respectively. Annual egg mass counts per m^2 of foliage were 10, 29 and 7, 1981 to 1983.

The Shasta-Trinity National Forests, in cooperation with the other land managers, conducted an environmental analysis (EA) that estimated the cost of controlling the infestation would be greater than the projected value of damage that would be prevented by treatment. This, plus the dramatic decline in numbers of egg masses, lead the Forest Supervisor to adopt the "defer action" alternative as the plan of management for the infestation for 1984. Further monitoring of the insect population and extent of defoliation was a part of this decision.

The Insect - Choristoneura carnana californica[1/]

This budworm has been collected in the Coast Range of California as far south as Santa Cruz County. It also has been taken from Douglas-firs in Lake and Napa Counties and along the southern Cascade Range and the Sierran west slope as far south as El Dorado County (Powell 1980). The adult moths are brick red and heavily marked with white on the forewing. Markings vary from distinct to mottled bands. Wing spans range from 19 to 25 mm.

The life cycle of this budworm at Trinity Lake is not exactly known. However, as presently understood, the moths emerge from the pupal stage from mid-June through early July, and almost all die before the last week of July (Fig. 3). During this period, light green eggs are laid in masses on the underside of needles. Within a short time the larvae develop and hatch from the eggs. The newly hatched larvae do not feed, but rather seek protection among lichens and bark scales, where they remain in silken-shelters from July to late March of the following year.

When weather conditions become suitable in the spring, the larvae mine into developing male and female flowers. When this preferable food source is scarce or absent, they mine in the tips of old needles until the vegetative buds begin to swell, whereupon they transfer to these buds. It is thought that young larvae do not develop rapidly on older needles and the survival rates decline when this food source must be utilized. Larvae prefer to feed upon new foliage

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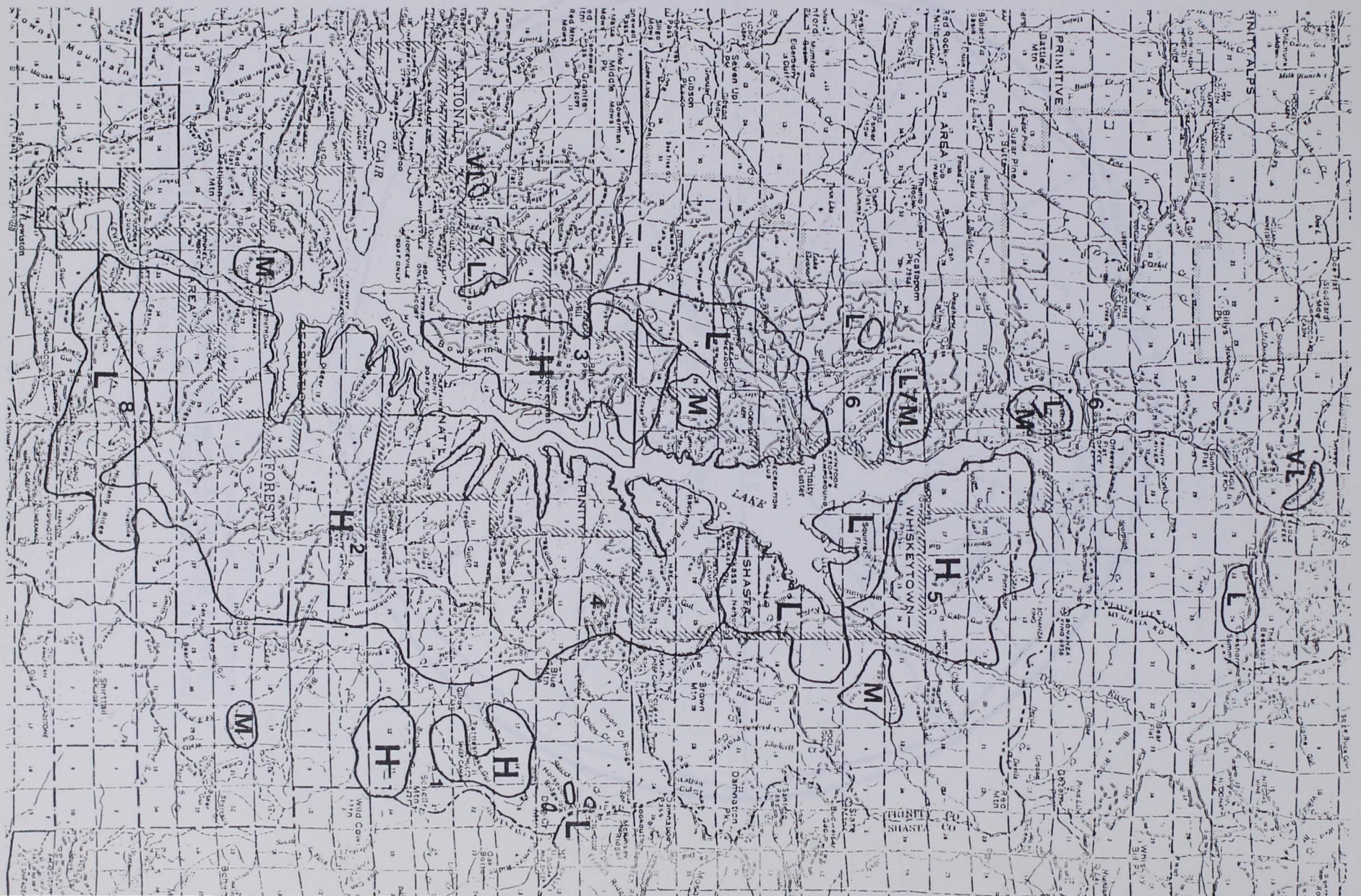
1/ There is no approved common name from Choristoneura carnana californica. The name western spruce budworm for C. occidentalis presently is being re-evaluated because "spruce" is not descriptive of the insect in the western United States. Therefore, "western budworm" is used in a general sense, not as an accepted common name.

Figure 2. Trinity Lake western budworm infestation. Weaverville District, Shasta-Trinity National Forests, 1983. VL = very light, L = light, L/M = light to moderate, M = moderate, H = heavy defoliation. //// Boundary, National Recreation Area.



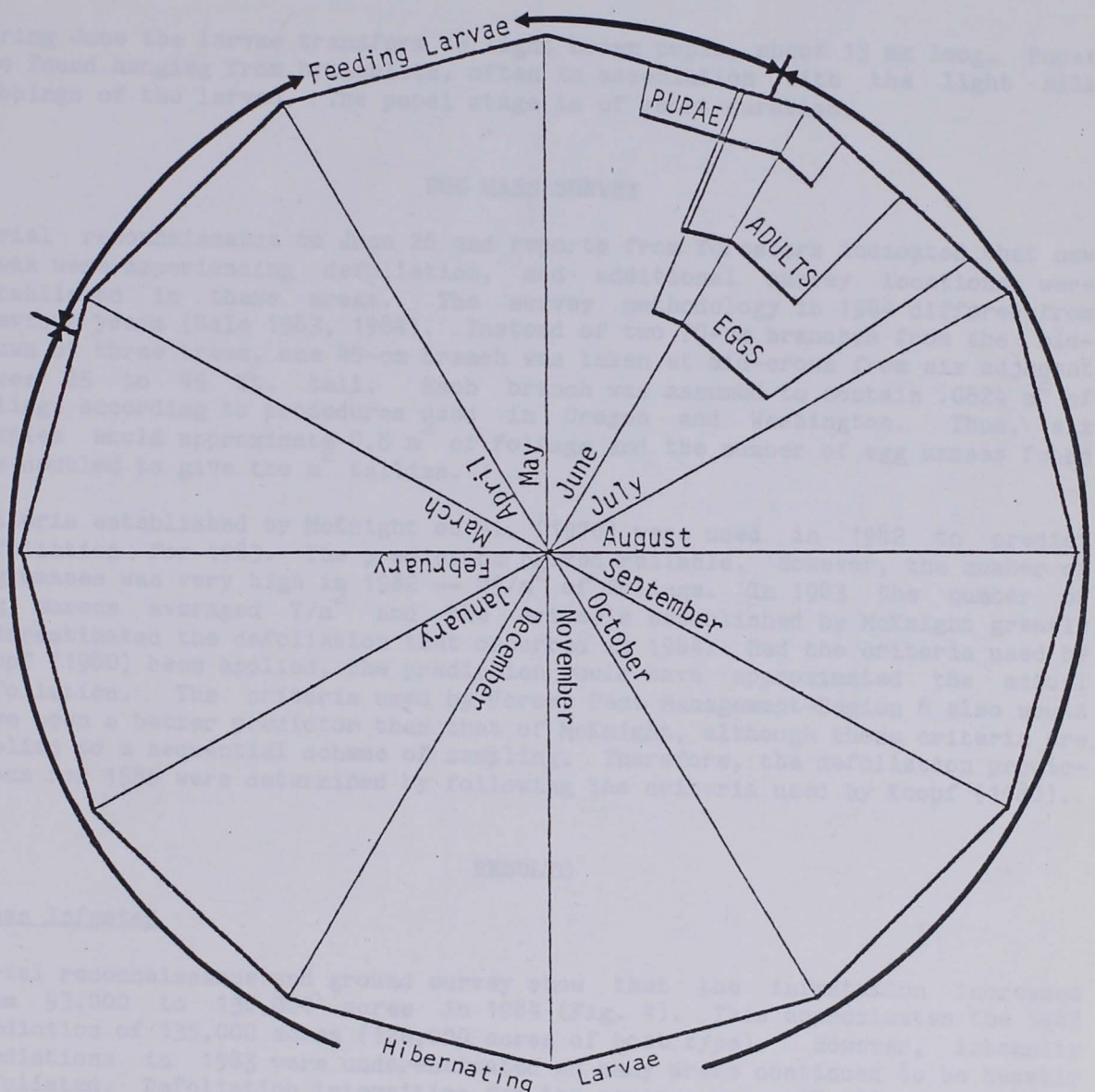


Figure 3. General representation of the seasonal occurrance of the budworm, Choristoneura carnana californica Powell, in the vicinity of Trinity (Clair Engle) Lake, Trinity and Shasta Counties, California.

throughout the spring. However, older needles are eaten by later larval stages if the population strips the new foliage. Larvae develop rapidly, and population suppression measures, if applied, would take place in late May or early June (Fig. 3).

During June the larvae transform to light brown pupae, about 13 mm long. Pupae are found hanging from branchlets, often in association with the light silk webbings of the larvae. The pupal stage is of short duration.

EGG MASS SURVEY

Aerial reconnaissance on June 26 and reports from foresters indicated that new areas were experiencing defoliation, and additional survey locations were established in these areas. The survey methodology in 1984 differed from previous years (Dale 1983, 1984). Instead of two 70-cm branches from the mid-crown of three trees, one 45-cm branch was taken at mid-crown from six adjacent trees 25 to 45 ft. tall. Each branch was assumed to contain .0824 m^2 of foliage according to procedures used in Oregon and Washington. Thus, six samples would approximate 0.5 m^2 of foliage and the number of egg masses found was doubled to give the m^2 tallies.

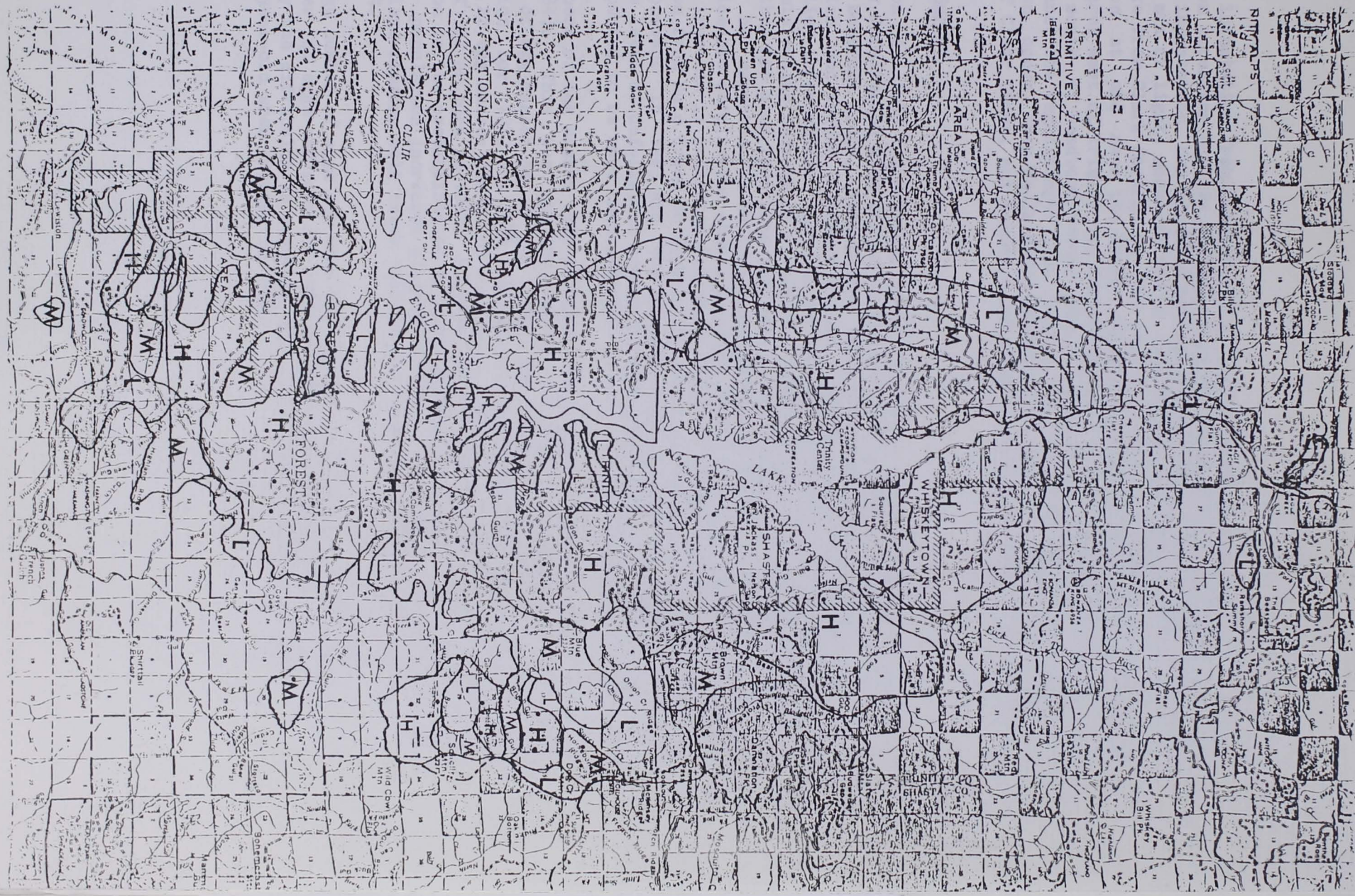
Criteria established by McKnight et al. (1970) were used in 1982 to predict defoliation for 1983. The prediction proved reliable. However, the number of egg masses was very high in 1982 -- 29/m^2 of foliage. In 1983 the number of egg masses averaged 7/m^2 and the criteria established by McKnight greatly underestimated the defoliation that occurred in 1984. Had the criteria used by Knopf (1980) been applied, the prediction would have approximated the actual defoliation. The criteria used by Forest Pest Management-Region 6 also would have been a better predictor than that of McKnight, although those criteria are applied to a sequential scheme of sampling. Therefore, the defoliation predictions for 1985 were determined by following the criteria used by Knopf (1980).

RESULTS

Areas Infested

Aerial reconnaissance and ground survey show that the infestation increased from 93,000 to 130,000 acres in 1984 (Fig. 4). This approximates the 1983 prediction of 135,000 acres (120,000 acres of host type). However, intensity predictions in 1983 were underestimated as many areas continued to be heavily defoliated. Defoliation intensities for the acreage were 27,500 acres (21%) light, 22,700 acres (17%) moderate, and 80,000 acres (61%) heavy. The light classification (1 to 33% loss of current foliage) increased 28%, the moderate (33 to 67% loss) increased 510%, and the heavy class (67 to 100% loss) increased 17%. The elevational range remained the same -- 2,200 ft. at Jennings Gulch to 5,200 ft. at Blue Mountain. Many south facing slopes are now as heavily defoliated as ridge tops and north-facing slopes. Moderate damage to white firs was apparent for the first time in the vicinity of Blue Mountain. Heavy defoliation occurred in white fir along the ridge south of the South Fork of Stacey Creek.

Figure 4. Trinity Lake western budworm infestation, Weaverville District, Shasta-Trinity National Forests, 1984. L = light, L-M = light to moderate, M = moderate, H = heavy, O = no defoliation. //// Boundary, National Recreation Area. Dots = sample locations



The patch infestation from Swift Creek to Coffee Creek is now part of a general infestation extending 4 miles westward from the upper arm of the lake. A new northern infestation has appeared between Trinity River Campground and Ripple Creek. A mix of light, moderate and no defoliation now occurs on the west side of the lake from Clark Springs to the access road to Hayward Flat, while defoliation at and near the latter campground has intensified to heavy. The infested area west of Trinity Dam increased, and a new infestation has now appeared south of Deadwood Creek. The boundary on the southeast remains constant because the vegetational type changes. On the northeast, new areas of infestation occur from Fools Gulch southward through Bear Gulch and the upper reaches of Clear Creek, and across Clear Creek from Blue Mountain to Horsebone Ridge.

Egg Mass Survey

Defoliation in 1985 is expected to be similar to that of 1984. The areas of past heavy defoliation will remain in the areas of greatest impact -- Trinity Mountain, Bowerman Ridge, Clear Creek. However, defoliation in Halls Gulch and Fools Gulch and around Preachers Meadows Campground may soon be equivalent to these earlier infestations. The new to new egg mass ratios (Table 1) may be somewhat misleading because of an apparent underestimate of egg masses in 1983. However, they are such that some increase in the insect population and defoliation may be expected in Papoose, Digger-Bear Gulches, Van Ness, and Trinity Dam. Noticeable defoliation should increase near and north of Trinity Center. A large increase is indicated for Halls Gulch and Fools Gulch. The amount of defoliation from Mule Creek to Hayward Flat will increase, but the number of insects present in 1983 and 1984 indicate that impacts will remain slight in 1985. The level of defoliation around Blue Mountain has never been serious and is not expected to be more than moderate in spite of the 1984 ratios (Table 1).

Large numbers of egg masses were collected from many locations in 1982 (Dale 1983, 1984). This was not the case in 1983 and 1984 (Fig. 5). Whereas the histogram of egg masses per m^2 per plot was broadly defined in 1982, the distribution for 1983 and 1984 followed a J-shaped pattern. No plot averaged more than 22 egg masses per m^2 of foliage in 1983, while 44 of 72 plots had counts of 22 or more in 1982. Fourteen of 115 had 22 or more in 1984. Thus, in addition to the probability of an underestimate in 1983, it seems likely that the population increased slightly in 1984. The number of egg masses per m^2 of foliage remains well below 1982 levels, however -- 29 in 1982, 7 in 1983, 11 in 1984.

The average number of eggs per mass was similar to previous years (Table 2). The number of eggs per mass for 1981 is currently considered an underestimate created by the difficulty in counting eggs in partially collapsed masses that were one-year-old when counted in 1982.

TABLE 1. TRINITY LAKE WESTERN BUDWORM INFESTATION, 1984
EGG MASS RATIOS AND COMPARISON WITH 1982 AND 1983

Area Infested	Egg Masses (No.)/M^2 Foliage				
	Ratio - New:Old			Ratio - New:New	
	1982	1983	1984	83:82	84:83
1 Clear Creek	2.7:1	0.7:1	0.5:1	0.3:1	1.0:1
Wild Cow Mtn.	a/	1.4:1	0.6:1	a/	0.9:1
2 Trinity Mtn. Area	2.6:1	0.4:1	0.8:1	0.1:1	3.2:1
Papoose Creek	2.5:1	0.2:1	0.5:1	0.2:1	3.1:1
Digger-Bear Gulches	2.8:1	0.4:1	1.4:1	0.1:1	4.1:1
Van Ness	2.9:1	0.5:1	0.8:1	0.1:1	5.0:1
Feeney	2.0:1	0.5:1	0.6:1	0.2:1	2.0:1
Southeast	2.6:1	0.5:1	1.3:1	0.2:1	1.9:1
3 Bowerman Ridge and Norwegian Ranch	4.4:1	1.1:1	0.7:1	0.4:1	0.8:1
Bowerman	4.4:1	1.1:1	0.7:1	0.4:1	0.7:1
Norwegian	a/	1.2:1	0.8:1	a/	0.8:1
4 Blue Mtn. and Nelson Gap	4.3:1 b/	1.1:1	1.6:1	0.3:1 b/	1.7:1
5 Squirrel Flat, Cedar Creek and Halls Gulch	a/	1.4:1	0.6:1	a/	0.6:1
Squirrel & Cedar	a/	1.6:1	0.2:1		0.2:1
Halls & Fools Gulch	a/	0.7:1	0.9:1		3.2:1
6 Swift Creek to Coffee Creek	a/	3.7:1	1.0:1	a/	1.3:1
Trinity R. Campground to Ramshorn		5.7:1	1.5:1		1.5:1
7 Mule Creek to Hayward Flat	a/	1.1:1 c/	0.8:1	a/	3.2:1 c/
8 Southern Area	a/	0.7:1	1.2:1	a/	1.9:1
Keno to Deadwood	a/	0.7:1	1.1:1		1.9:1
Trinity Dam	a/	0.7:1	1.6:1		3.3:1 d/
SUMMARY	2.8:1	0.9:1	0.8:1	0.2:1	1.4:1

a. First sampled in 1983.
b. Blue Mtn. (plots 52 to 55) only.
c. Ratios based on low numbers of egg masses.
d. Based upon one plot only (#95).

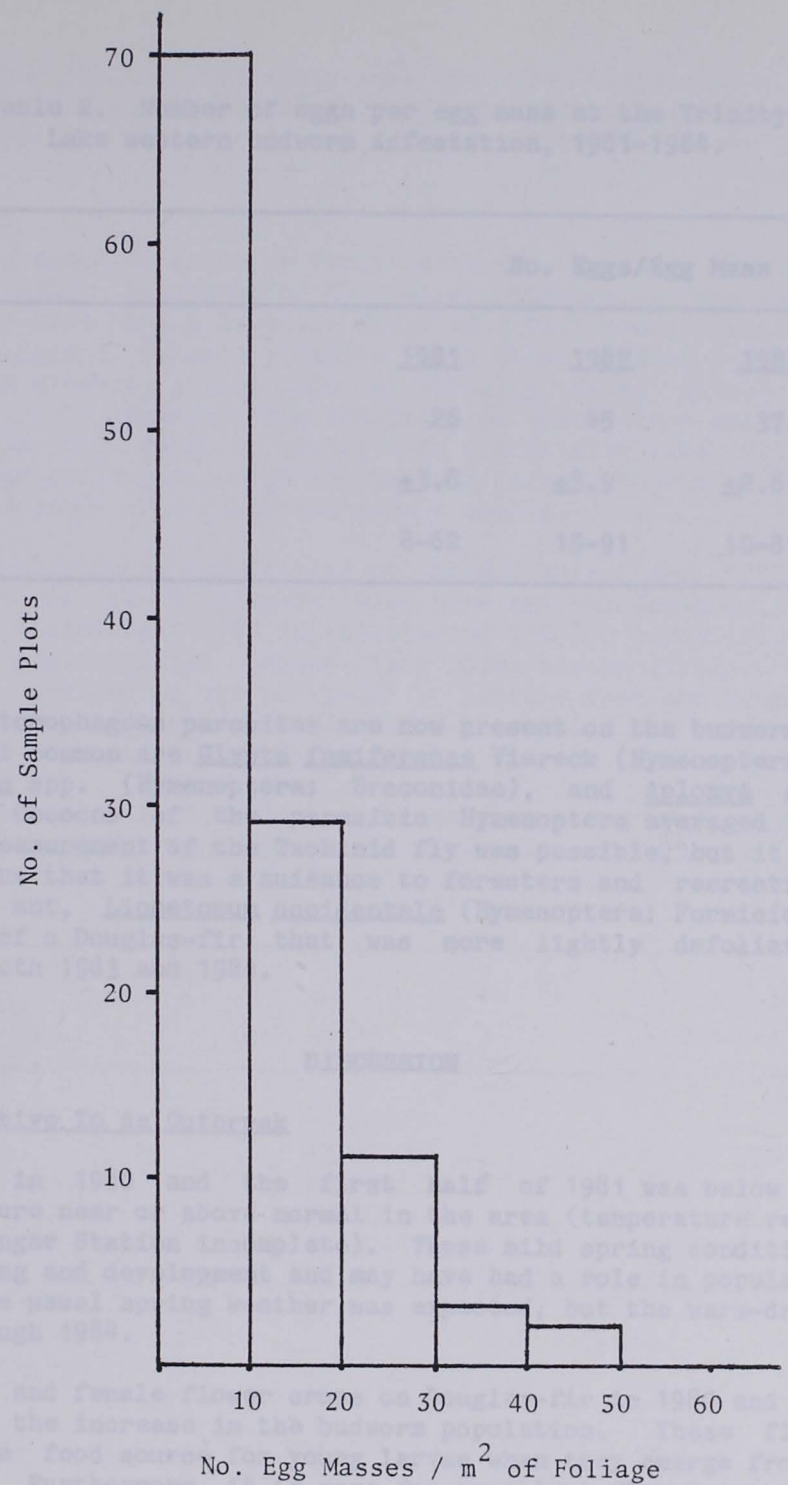


Figure 5. Frequency of sample plots by egg mass counts, 1984. Average = 11, range = 0 to 48 egg masses / m^2, n = 115.

Table 2. Number of eggs per egg mass at the Trinity Lake western budworm infestation, 1981-1984.

	No. Eggs/Egg Mass			
	1981	1982	1983	1984
X	26	45	37	42
Std. error	±3.8	±3.9	±2.6	±4.2
Range	8-62	15-91	10-81	15-94

Parasites

A number of entomophagous parasites are now present on the budworm population. The three most common are Glypta fumiferanae Viereck (Hymenoptera: Ichneumonidae), Apanteles spp. (Hymenoptera: Braconidae), and Aplomya sp. (Diptera: Tachinidae). Cocoons of the parasitic Hymenoptera averaged 12.5 per m^2 of foliage. No measurement of the Tachinid fly was possible, but it was so common during late June that it was a nuisance to foresters and recreationists. The velvety tree ant, Liometopum occidentale (Hymenoptera: Formicidae) was taken from the bole of a Douglas-fir that was more lightly defoliated than its neighbors in both 1983 and 1984.

DISCUSSION

Factors Conductive To An Outbreak

Precipitation in 1980 and the first half of 1981 was below normal, while temperatures were near or above normal in the area (temperature records at the Weaverville Ranger Station incomplete). These mild spring conditions can favor budworm feeding and development and may have had a role in population release. A return to the usual spring weather was expected, but the warm-dry pattern has continued through 1984.

The heavy male and female flower crops on Douglas-fir in 1980 and 1982 may have contributed to the increase in the budworm population. These flowers are a very favorable food source for young larvae when they emerge from hibernation in the spring. Furthermore, it is rare for excellent flower crops to occur on Douglas-fir in such close succession. The Douglas-fir cone crop was very poor throughout California in 1983, and absent in the infested area. In 1984 the flower crop was good around the infestation, but not within the infestation. It was assumed that this was because of past and current feeding by the budworm.

The history of the area has previously been described (Dale 1983). The forest in the Trinity Lake area has become more susceptible to the budworm because of the development of numerous stands with canopies of two and three tiers.

Trends

The most pressing question asked by forest managers has been, "How long will the infestation last?" Outbreaks of the western budworm, C. occidentalis, last from two years to more than a decade. Those of a California species, the Modoc budworm, C. retiniana (Wlsm), usually last three to four years. Lacking a precedent for the present infestation at Trinity Lake, either possibility seemed likely in 1983. However, the intensity of defoliation and the degree of population levels now make it likely that the Trinity Lake infestation will follow an outbreak cycle similar to the average infestation of C. occidentalis. Four or five more years of defoliation seem probable.

The EA of 1983 projected an infestation of 180,000 acres for 1985. However, the distribution of the Douglas-fir host type and the decline in the rate of acreage increase indicates a 1985 infestation of 140,000 acres (Fig. 6, Table 3). Only two possibilities beyond this level appear likely. One would be additional acres involved in the northeast -- Sanford Pass and Damnation Peak. The other would be additional acres south of the Lake along Buckeye Ridge - an occurrence nearer areas of greater settlement.

Table 3. Extent of defoliation by the western budworm, Choristoneura carnana californica, on the Weaverville District, Shasta-Trinity National Forests

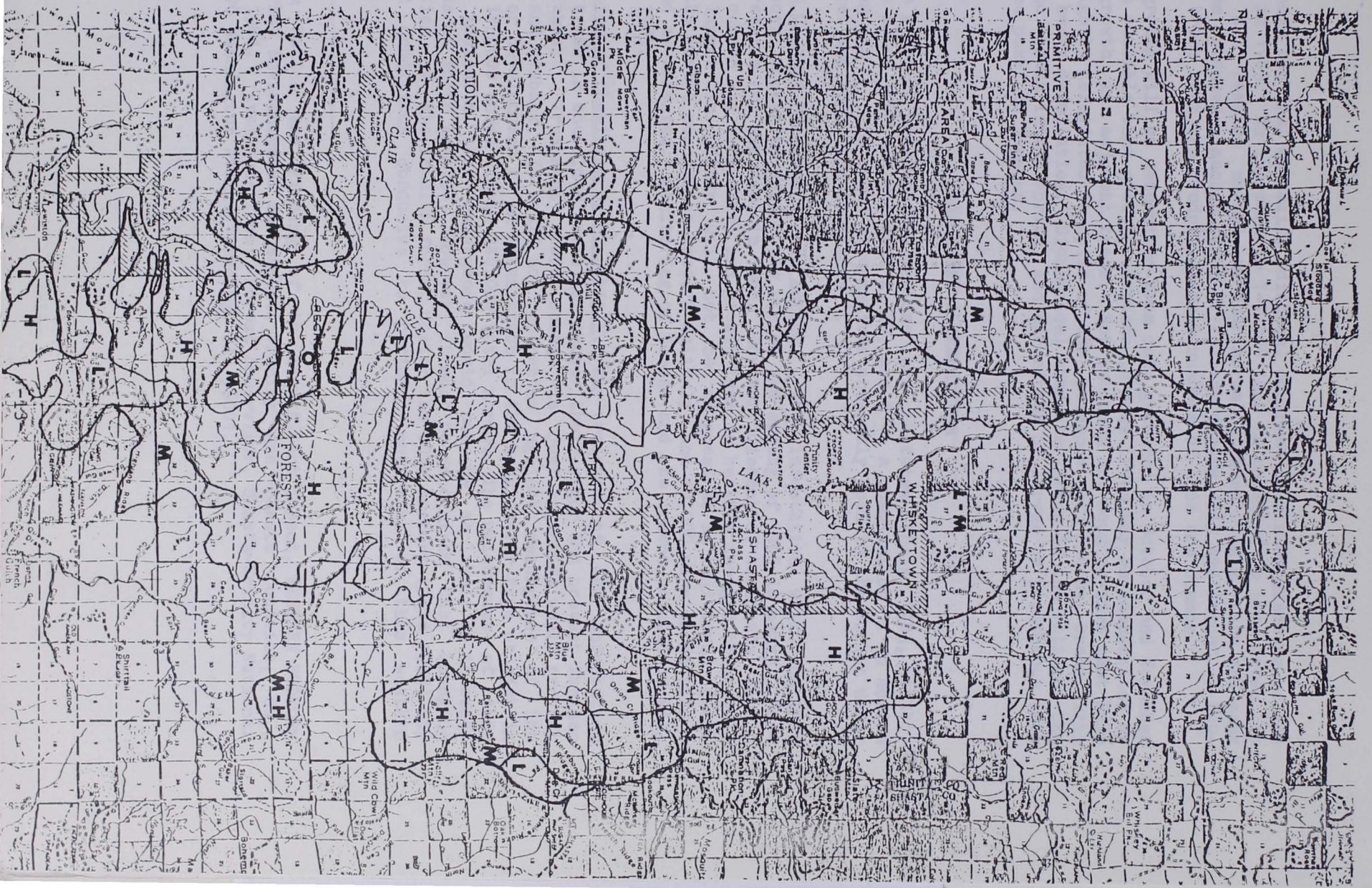
Year	Acres	Percent Increase
1981	5,500*	--
1982	33,000	500
1983	93,000	180
1984	130,000	40
1985	140,000**	8

* estimated
** predicted

Status of the Host

Whereas the most serious damage has been in sapling and small poles, Douglas-firs in the larger pole-size classes and some small sawtimber trees are now severely defoliated over 1/3 or more of their crowns. Suppressed and very small roadside trees are frequently 2/3 to 3/4 defoliated in the areas classed as heavily defoliated. Tree mortality has not appeared and is not expected in

Figure 6. Predicted defoliation for 1985, Trinity Lake western budworm infestation, Weaverville District, Shasta-Trinity National Forests. L = light, L-M = light to moderate, M = moderate, H = heavy, 0 = no defoliation. //// Boundary, National Recreation Area.



1985. Sporadic terminal mortality (dieback) occurred to a stem diameter of 1/4 to 3/8 inch in 1983. An increase to 1-1 1/4 inch is expected in some trees in 1984. Bud set remains normal or near normal on many Douglas-firs and many smaller trees produced a second flush of foliage during July and August. However, small trees that are producing small numbers of buds are common.

Impacts on growth will be determined from data gathered in October and November 1984. It is possible that growth reduction in some trees may be compensated by increased growth in adjacent trees. Not uncommon are Douglas-firs that have been only lightly defoliated in spite of the presence of nearby trees with moderate or heavy defoliation. Biochemical characteristics of the foliage, the time of bud break in the spring, and harvesting of larvae by predaceous ants are but three possible reasons.

MANAGEMENT ALTERNATIVES

Alternatives given in previous evaluations are restated (Dale 1983, 1984). However, the EA of 1984 has selected A, B2, and E -- a combination of no action and spraying Bt -- as the alternatives presently open to the Forest under present market and social determinants[2/].

A. Maintain Current Management - No Action. The infestation will continue unless budworm mortality during the winter and spring of 1985 is heavy. Mortality of trees is not expected in 1985. However, dieback of terminals should become more common and extensive, and growth loss in heavily damaged trees will continue. Impact in stands will not be as great as in individual trees. Decline in the insect population appears unlikely, and 10,000 more acres will be classified as infested. Monitoring of damage and the insect population will continue in 1985.

B. Application of Chemicals or Microbials. Any treatment of the infestation would allow trees in the older areas to recover their vigor and prevent further terminal dieback. Treatment where damage is just beginning would prevent growth loss and dieback. It would not guarantee against resurgence of the population or development of an infestation in the Douglas-fir type at risk in the area -- 185,000 acres within 240,000 total acres. The uniqueness of this infestation indicates that resurgence would not be as likely as in other western areas of North America. However, it must be recognized that changing characteristics of the Trinity forest during the 20th century (Dale 1983) may have created conditions conducive to periodic outbreaks of this western budworm.

2/ Decision Notice and Finding of No Significant Impact, WESTERN BUDWORM MANAGEMENT PLAN Environmental Assessment, Trinity and Shasta Counties, Ca., April 16, 1984. Available from: Forest Supervisor, Shasta-Trinity National Forests, 2400 Washington Avenue, Redding, CA 96001.

1. Aerial Application of Chemical Insecticides. A carefully timed and applied aerial application of a chemical insecticide will protect foliage from excessive defoliation and thus reduce damage. Results from suppression projects in other regions indicate more than one application may be required to achieve protection during an outbreak period.

Insecticides registered for use against the western budworm are:

a. Carbaryl (a carbamate insecticide). The Sevin-4-oil^{R} formulation of carbaryl has given consistently satisfactory results when properly applied and is the insecticide most commonly used against budworm infestations in western North America. Fairly broad-spectrum and relatively nonpersistent, it is only moderately toxic to warm-blooded animals and presents little hazard to mammals and birds when used at the registered rate. In contrast, carbaryl is toxic to fish, aquatic insects, and wild and domestic insect pollinators. No lasting unacceptable adverse environmental effects have been identified at the registered dosage rate.

b. Acephate (an organophosphate insecticide formulate and marketed as Orthene^{R} - 75 or 95%). Acephate is a broad-spectrum insecticide of moderate persistance. Residues degrade fairly rapidly (4 to 15 days) and are not passed up the food chain. It has a moderate acute toxicity to warm-blooded animals and a very low toxicity to fish and other aquatic organisms. Application of the water based formulations require careful selection of aircraft and specific procedures to acheive an acceptable population reduction (Fellin et al., unpublished manuscript, Canada/US Spruce Budworm Program, CANUSA). At the registered dosage rate no lasting unacceptable adverse environmental effects have been observed.

c. Malathion (an organophosphate insecticide). Malathion is a nonpersistent, broad-spectrum insecticide, registered for use against numerous insect pests, and is probably the most widely accepted insecticide. It is less toxic to warm-blooded animals than most other organophosphorus compounds. When applied against the western budworm, previous results have not been consistent and it has not been used since 1976 (Fellin et al., unpublished manuscript, Canada/US Spruce Budworm Program, CANUSA).

d. Mexacarbate (a carbamate insecticide). Mexacarbate was recently re-registered for western budworm control as Zectran^{R} DB. Zectran has a very low dermal toxicity to mammals and is nonpersistent, lasting only a few hours in full sunlight. It also is degraded by biological systems. Zectran is highly toxic to western budworm, especially sixth instars, and can be used in very small amounts (Fellin et al., unpublished manuscript, Canada/US Spruce Budworm Program, CANUSA).

2. Aerial Application of Bacillus thuringiensis (B.t.). This is a naturally occurring aerobic, spore- and crystal-forming pathogen that affects only insects in the order Lepidoptera. Once ingested, the interaction of digestive juices with the crystals and spores ruptures the gut wall. Feeding ceases within a few hours after ingestion, although affected insects may not die for several days.

The formulations Dipel[R] and Thuricide[R] are registered for use against the western budworm. The use of B.t. has been variable because the results of past applications have been erratic and the cost of B.t. has been high compared to chemical insecticides. But the cost of B.t. is now near that of chemical insecticides, and recent tests have shown that B.t. can be effective at higher dosages. B.t. is especially useful in and around sensitive areas and where off-target drift is unacceptable, where other pesticides are restricted, and where no treatment would be the only other alternative (Fellin et al., unpublished manuscript, Canada/US Spruce Budworm Program, CANUSA).

C. Biocontrols. Budworms have a number of natural regulating factors -- predators, parasites, weather. Predators such as ants and birds can be important in maintaining low budworm densities, but parasites are usually not a major source of mortality. Unfortunately, the techniques are not available to augment the influence of predators on an outbreak, and there is nothing to be done about the weather. The combined effects of all these natural factors can be responsible for the waning of budworm populations. But the combined effect of natural agents does not prevent or reduce population resurgences when climatic and forest/stand conditions are favorable to the insect.

D. Silvicultural Treatment. Addressing a current insect infestation with silvicultural manipulations is impractical. However, silviculture can be quite useful in the long-term. Greater species diversity could be created by greater use of ponderosa pine and other species in reforestation. The abundance of heavy infestations in stands with multilayered crown canopies indicates that this condition should be addressed in future management plans in order to reduce stand susceptibility. Even-aged strategies do appear to be particularly effective against budworm, although they may not be best in all stands or under all conditions. Thinnings would be done to remove stressed trees, improve tree vigor, and maintain species diversity.

E. Combination. Budworm populations in areas such as Squirrel Flat appear to be declining while populations in other areas are increasing. Some control action such as the use of B.t. could be used on the latter, while the no action alternative could be selected for the areas of decline.

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